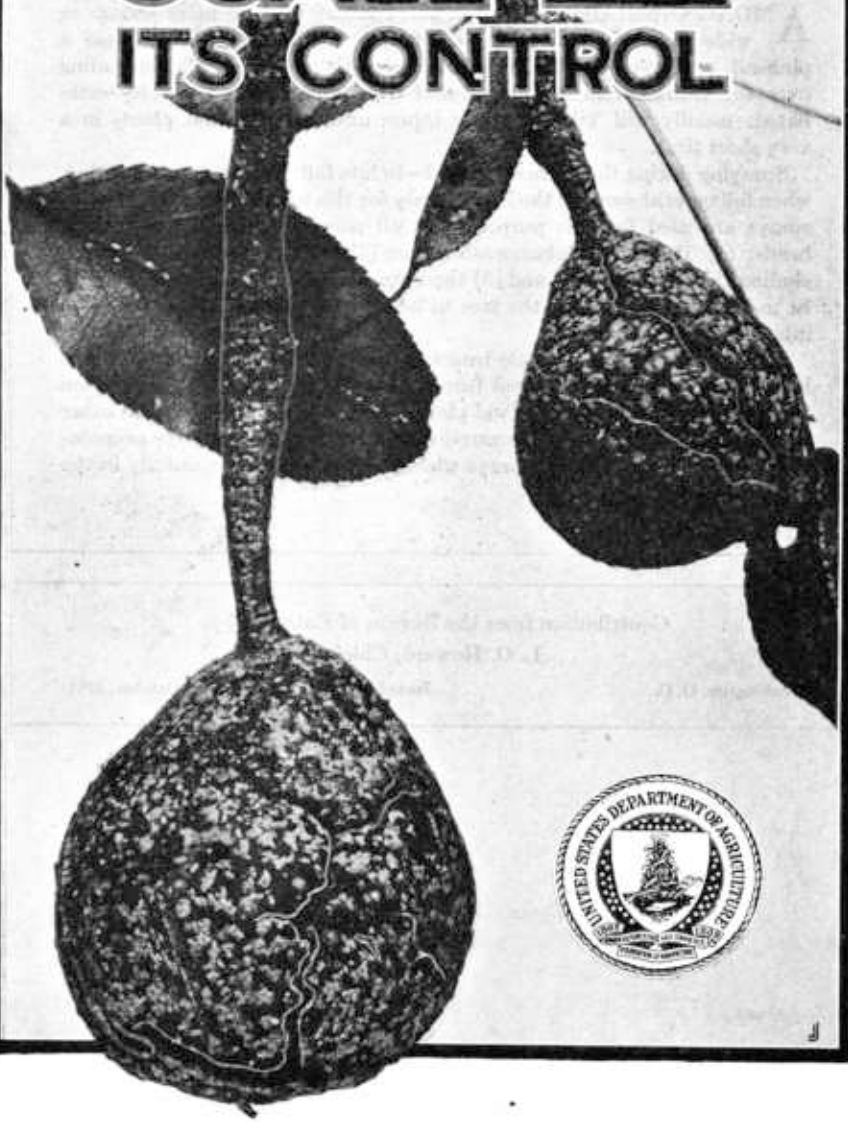
FARMERS' BULLETIN 650
UNITED STATES DEPARTMENT OF AGRICULTURE

SAN JOSE SCALE AND ITS CONTROL



AMONG ORCHARD PESTS in this country few are more serious or widespread than the San Jose scale. Although no larger than a pinhead, and even smaller, it multiplies with great rapidity, spreading over the trunk, branches, leaves, and fruit, and, unless promptly combated, usually will kill or greatly injure infested trees and plants in a very short time.

Spraying during the dormant period—in late fall, winter, or early spring, when foliage is absent—is the best remedy for this insect. Several different sprays are used for this purpose, but all may be grouped under three heads: (1) The lime-sulphur wash series; (2) the petroleum-oil series (including the miscible oils); and (3) the soap washes. The kind of spray to be used will depend upon the tree to be sprayed and its susceptibility to injury by spray mixtures.

Besides describing this scale insect and its life history and habits, this bulletin shows how it is spread from orchard to orchard and from region to region, lists its numerous food plants, discusses the parasitic and other insect enemies which help in controlling it, and describes fully the preparation and application of the sprays which are used most successfully in the warfare against it.

Contribution from the Bureau of Entomology,
L. O. Howard, Chief.

Washington, D. C. Issued Mar. 30, 1915; revised October, 1919

THE SAN JOSE SCALE AND ITS CONTROL.[1]

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CONTENTS.

CHARACTER OF INJURY.

THE San Jose or Chinese scale [1] infests practically all portions of its host plants that are above ground—the trunk, limbs, and branches—and when abundant it may occur on the leaves and fruit. Injury results from the extraction, by the scale insects, of the juices of the plant. At first this merely checks growth, but as the insects increase in number the speedy killing of the branches and twigs follows, resulting finally in the death of the plants. In addition to the extraction, by the scales, of sap as food, the puncturing of the bark by the slender sucking mouth parts results in a diseased and often pitted condition; the inner bark, or cambium, shows a reddish discoloration, as exposed in cutting with a knife, and the bark itself may crack, in stone fruits exuding drops or masses of gum. A reddening effect is also much in evidence as red rings around the scales on the bark, especially of the apple and pear, and on the fruits of these plants, though not characteristic of any one scale species.

On peach the scales have a tendency to infest to a greater extent the older limbs and branches than the newer growth, such as the wood a year old. On apple and pear the terminal twigs are quite generally infested, and many of the young may find their way to the fruit, settling principally in the calyx and stem cavities. Most varieties of fruit trees, infested from the nursery perhaps, never reach fruiting condition unless treatment be given them. Peach trees will

[1] *Aspidiotus perniciosus* Comstock; order Hemiptera, suborder Homoptera, family Coccidae.

usually be killed in a few seasons, while pear or apple trees will maintain a feeble existence much longer.

The San Jose scale, because of its great similarity to certain other scale insects, may not be positively determined except by specialists. Diseased and dying branches showing severe scale infestation furnish strong presumptive evidence of the presence of this pest, but specimens of infested twigs should be promptly submitted to a qualified person for examination.

The appearance of a 3-year-old peach tree, presumably infested from the nursery, is shown in figure 1. The principal limbs have

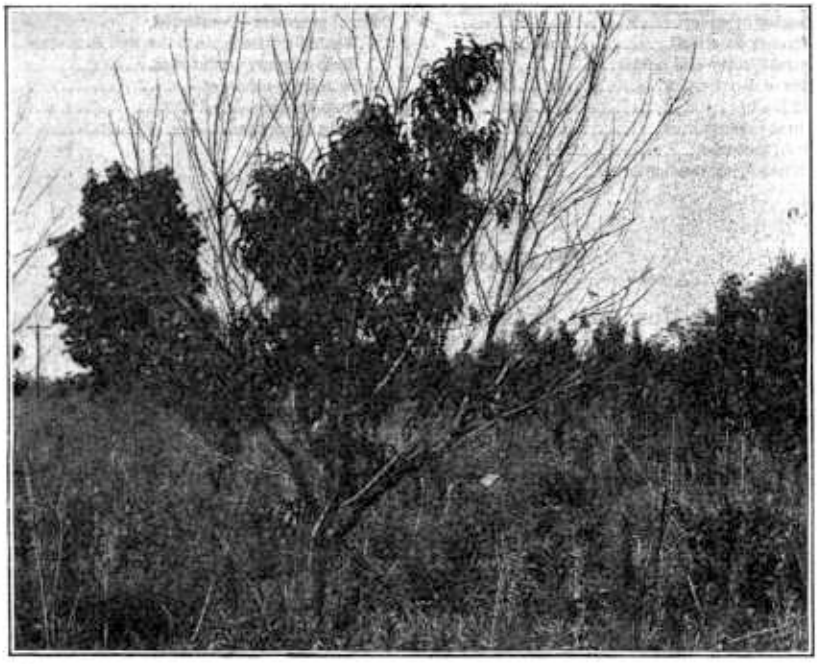

FIG. 1.—Appearance of 3-year-old peach tree badly injured by the San Jose scale, the larger branches having been killed.

already been killed, although new shoots have developed. A tree in this condition generally may be saved by thoroughly pruning out the dead and badly injured wood and afterwards controlling the scale by spraying. The condition of this tree a year later is shown in figure 2, indicating the recovery following pruning and spraying, original infestation of which came from an adjacent orchard. Even in the case of badly infested peach trees it is very probable that dehorning, thorough spraying, and stimulation of growth with a nitrogenous fertilizer, as nitrate of soda, would bring the trees into condition again. It is a matter of judgment, however, whether trees so seriously injured should not be removed.

The injury to an apple orchard, in which the trees were infested from outside sources four or five years earlier, is shown in figure 3. Although many of the limbs and branches are injured or killed, such trees may be brought into vigorous condition by thorough pruning, stimulation with nitrogenous fertilizers, and insuring the control of the insect in the future.

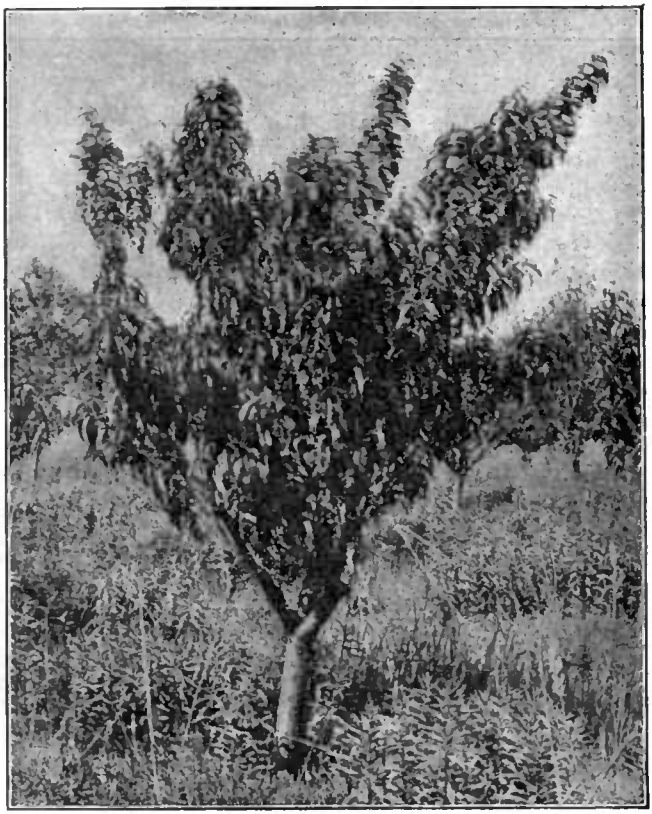

FIG. 2.—Appearance of peach tree shown in figure 1, one year later. The dead and injured wood was thoroughly pruned out and the San Jose scale controlled by spraying.

THE INSECT DESCRIBED.

The mature San Jose scale is small, grayish in color, circular in outline, somewhat convex, and with a nipple-like prominence in the center. The female scale is about 1 millimeter in diameter (about the size of a pinhead); the male scale is much smaller and elongate. (See figs. 4 and 5.) The insect proper is beneath the so-called scale, this being simply a waxy covering secreted by the soft, helpless, yellow "louse" for its own protection. Where trees and plants are but slightly infested the presence of the scale is not readily detected by

the casual observer, but in the case of severe infestation (see fig. 5) the bark of the tree and limbs will present an ash-gray appearance, and on closer examination will be found thoroughly incrusted with the scales, which, when scraped with a knife, will produce a yellowish, oily fluid. When the scales are abundant on the tree the foliage also will be thoroughly infested, giving it a spotted and diseased appearance readily observable some feet away.

FIG. 3.—Appearance of apple orchard badly infested by the San Jose scale; many of the limbs and branches have been killed.

NATURAL HISTORY AND HABITS.

The San Jose scale passes the winter in an immature condition fixed to the bark of the host plant, the small dark-gray or blackish scales being just discernible with the unaided eye. In early spring, with the ascent of the tree's sap, the growth of the scale begins, and early in April, in the latitude of Washington, D. C., the small, two-winged, active males issue from the male scales. After mating with the females the males die. The females continue to grow and in about a month begin the production of living young—minute, yellow, oval creatures—which by very close observation may be distinguished without the aid of a hand lens, crawling here and there on the infested plants in an effort to find a suitable place for settlement. The young insect is active for some hours, but soon settles, pushes

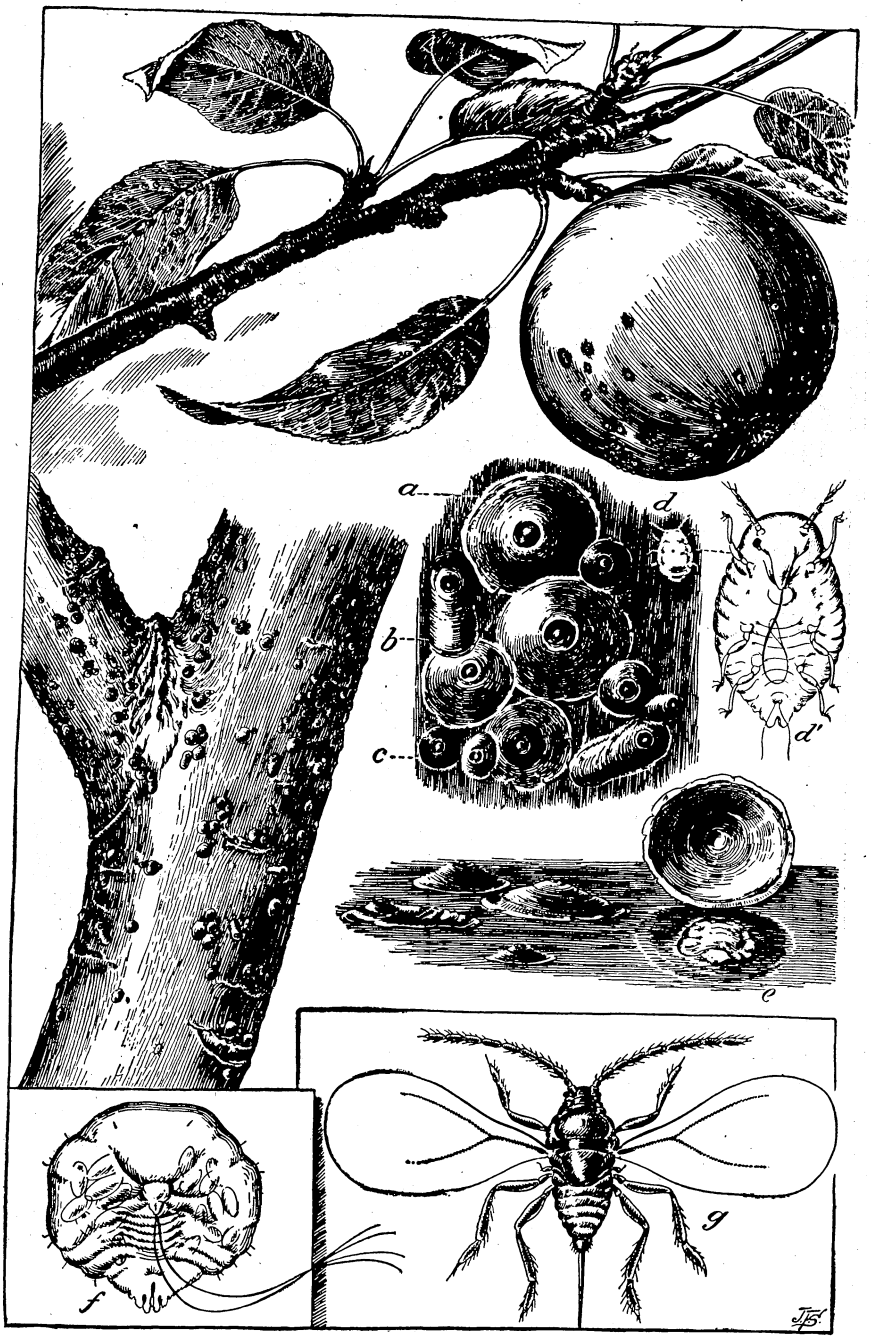

FIG. 4.—San Jose scale: *a*, Adult female scale; *b*, male scale; *c*, young scales; *d*, larva just hatched; *d'*, same, much enlarged; *e*, scale removed, showing body of female beneath; *f*, body of female insect, more enlarged; *g*, adult male of the San Jose scale.

its slender, threadlike beak into the plant, and begins to feed by sucking out the sap. After this there is no further movement from place to place, and the waxy covering, which often begins to develop before the insect has settled, soon covers it completely.

In about 12 days the insects molt, and from this time on the male and female scales may be readily distinguished. From 8 to 10 days later the males change to pupæ, and in from 24 to 26 days from birth the adult males emerge and fecundate the females, which in turn reach maturity and begin the production of young in from 33 to 40

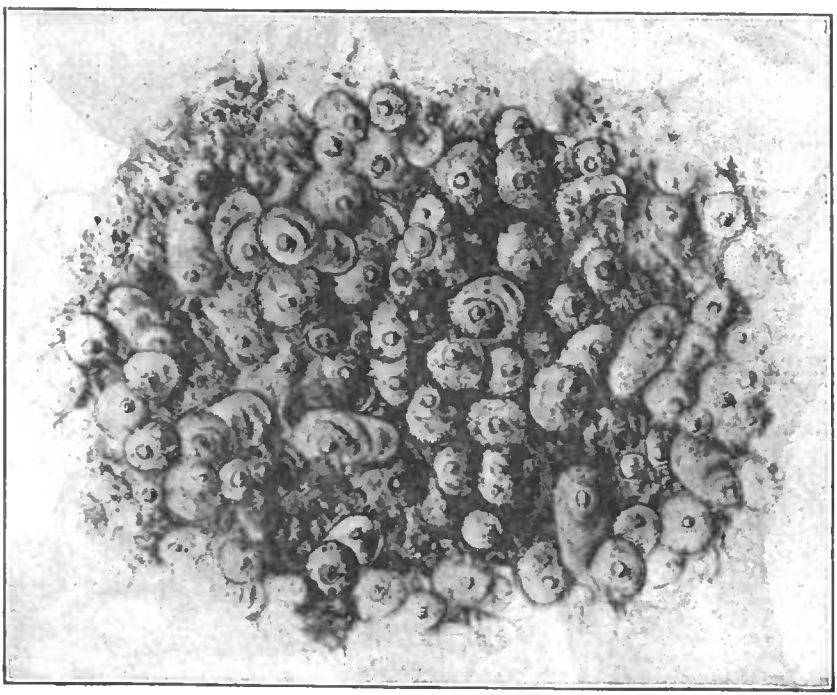

FIG. 5.—Enlarged view of a group of San Jose scales.

days from birth. An individual female may give birth to about 400 young, and as the life cycle of the female covers but a few weeks there may be several generations a year. The progeny from one parent during the season have been estimated at 1,608,040,240 females. It is thus easy to understand why prompt remedial measures are necessary. With the approach of the cool weather of fall the scales in all stages enter hibernation. Most of the older and also most of the younger individuals perish during the winter, the survivors being those about one-third or one-half grown.

MEANS OF DISTRIBUTION.

The San Jose scale is distributed from one region to another principally on nursery stock, scions, or budding and grafting material. Laws are in force in the majority of States requiring the inspection of nurseries and the destruction of infested stock. Traffic in nursery produce is permissible only under the certificate of an official entomologist or inspector that the stock is free from the scale. In addition, most nurserymen fumigate the plants, before distribution, with hydrocyanic-acid gas.

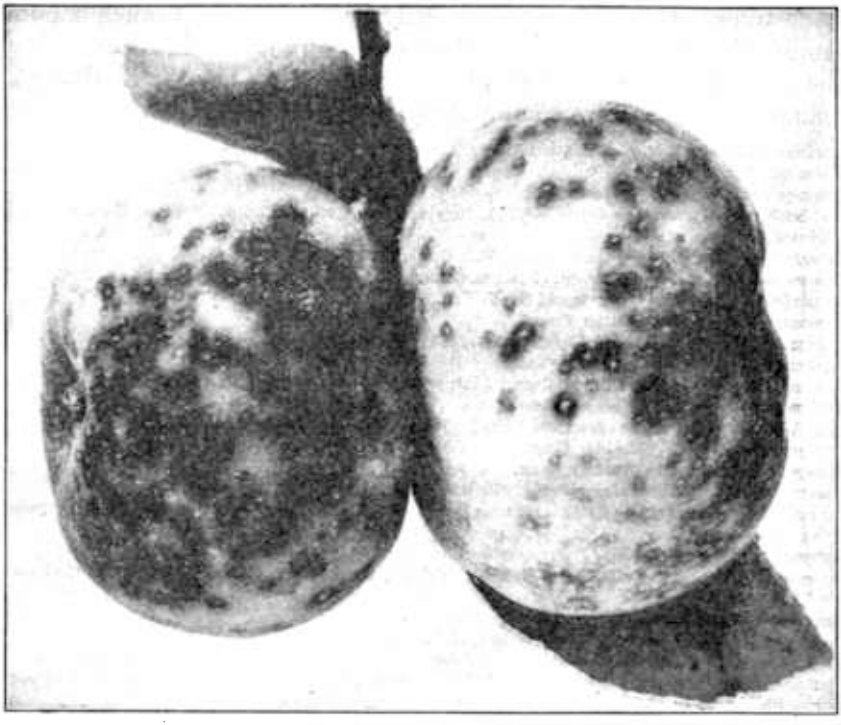

FIG. 6.—Appearance of apples infested with the San Jose scale.

After the insect once becomes established in a locality it spreads by various agencies. It is capable of movement only during a short period after birth. During this crawling stage the insects are able to pass from tree to tree where the limbs are in contact, but it is principally distributed by other agencies. Prominent among these are birds, which may alight upon infested trees, where the young insects may crawl upon their feet and be subsequently deposited in other trees, sometimes at distances quite remote. The young probably are blown by strong winds from tree to tree; and they are carried by insects, such as grasshoppers, ladybird beetles, ants, etc.

The crawling "lice" may be transported considerable distances on the clothing of man, on vehicles, or on horses or other live stock which may be in orchards for any purpose.

The suggestion that the insect may be disseminated by means of scale-infested fruit (see fig. 6) has been frequently made, but it is the consensus of opinion among American entomologists that this danger is negligible.

FOOD PLANTS.

The San Jose scale infests practically all deciduous fruit trees, such as apple, pear, peach, plum, etc., and also many ornamental and shade trees. It is, however, seriously destructive to a much smaller number than that upon which it may actually maintain its existence. The following list of food plants, as compiled by Dr. W. E. Britton,[1] includes those that are commonly or badly infested:

Acacia sp. Lintner, Felt, N. Y.; Alwood, Va.
Akebia sp. Felt, N. Y.
Akebia quinata Decaisne. Alwood, Va.
Shad-bush (*Amelanchier canadensis* Medic.), Juneberry, and other species. Britton, Koehler, Conn.; Alwood, Va.
Citrus trifoliata Linn. Scott, Ga.; Alwood, Va.; Gossard, Fla.
Cornus alba Linn. var. *sibirica* Lodd. Britton, Conn.
Cornus baileyi Coult. & Evans. Gould (in N. Y.)
Cornus sanguinea Linn. Britton, Conn.
Cotoneaster sp. Britton, Conn.; Lintner, Felt, N. Y.; Card, R. I.
Cotoneaster vulgaris Lindl. Alwood, Va.
Hawthorn (*Cratægus* sp.). Britton, Conn.; Lintner, Felt, N. Y.; Alwood, Va.; Smith, N. J.
Cratægus cordata Soland. Koehler, Conn.
English hawthorn (*Cratægus oxyacantha* Linn.). Britton, Koehler, Conn.
Cratægus coccinea Linn. Koehler, Conn.
Cratægus crus-galli Linn. Koehler, Conn.
Common quince (*Cydonia vulgaris* Pers.). Britton, Conn.; Lintner, N. Y.; Alwood, Va.
Japanese or flowering quince (*Cydonia japonica* Pers.). Britton, Koehler, Conn.; Lintner, N. Y.; Alwood, Va.; Johnson, Md.
European purple-leaved beech (*Fagus sylvatica* Linn. var. *purpurea* Ait.). Smith, N. J.
Japanese walnut (*Juglans sieboldiana* Maxim). Britton, Conn.; Alwood, Va.; Sherman, N. C.; Smith, N. J.
Common privet (*Ligustrum vulgare* Linn.). Alwood, Va.
Poplar (*Populus* sp.). Britton, Conn.; Smith, N. J.; Sanderson, Del.; Felt, N. Y.
Carolina poplar (*Populus deltoides* Marsh). Britton, Conn.; Rolfs & Quaintance, Fla.; Alwood, Va.
Lombardy poplar (*Populus nigra* Linn. var. *italica* Du Roi). Britton, Koehler, Conn.; Rolfs & Quaintance, Fla.; Alwood, Va.
Almond (*Prunus amygdalus* Stokes). Lintner, N. Y.; Alwood, Va.
Apricot (*Prunus armeniaca* Linn.). Lintner, Felt, N. Y.; Alwood, Va.; Smith, N. J.
Sweet cherry (*Prunus avium* Linn.). Britton, Conn.; Lintner, Felt, N. Y.; Alwood, Va.; Smith, N. J.; Cockerell, N. Mex.
Prunus pumila Linn. Koehler, Conn.
Sand cherry (*Prunus pumila* var. *besseyi* Waugh). Alwood, Va.
Purple-leaved plum (*Prunus cerasifera* Ehrh. var. *atropurpurea* Dipp. (*P. pissardi*). Britton, Conn.; Felt, N. Y.
European plum (*Prunus domestica* Linn.). Britton, Conn.; Alwood, Va.
Wild goose plum (*Prunus hortulana* Bailey). Alwood, Va.
Flowering almond (*Prunus japonica* Thunb.). Britton, Conn.; Felt, N. Y.
Beach plum (*Prunus maritima* Waugh). Koehler, Britton, Conn.
Peach (*Prunus persica* Sieb. & Zucc). Britton, Koehler, Conn.; Lintner, Felt, N. Y.; Alwood, Va. Cockerell, N. Mex.
Japanese plum (*Prunus triflora* Roxbg.). Britton, Koehler, Conn.; Alwood, Va.
Prunus serotina Ehrh. Koehler, Conn.

[1] Britton, W. E. List of hardy trees, shrubs, and vines commonly or badly infested [by the San Jose scale]. Conn. Agr. Expt. Sta., Rpt. for 1902, pt. II., 2d Rpt. State Entomologist, p. 132-138. 1903.

Chokecherry (*Prunus virginiana* Linn.). Koehler, Conn.
Hop tree (*Ptelea trifoliata* Linn.). Fernald, Mass.
Pear (*Pyrus communis* Linn.). Britton, Koehler, Conn.; Lintner, Felt, N. Y.; Alwood, Va.; Cockerell, N. Mex.
Sand pear, including Kieffer (*Pyrus sinensis* Lindl.). Alwood, Va.
Pyrus baccata Linn. Koehler, Conn.
Apple (*Pyrus malus* Linn.). Britton, Koehler, Conn.; Lintner, Felt, N. Y.; Alwood, Va.; Doten, Nev.; Cockerell, N. Mex.
Crab apple (*Pyrus* sp.). Britton, Conn.
Gooseberry (*Ribes oxyacanthoides* Linn.). Britton, Conn.; Lintner, Felt, N. Y.; Alwood, Va.; Troop, Ind.
Missouri or flowering currant (*Ribes aureum* Pursh.). Lintner, N. Y.
Currant (*Ribes rubrum* Linn.). Britton, Conn.; Lintner, Felt, N. Y.
Black currant (*Ribes nigrum* Linn.). Alwood, Va.
Rosa sp. Britton, Conn.; Lintner, N. Y.; Alwood, Va.; Cockerell, N. Mex.; Burgess, Ohio; Troop, Ind.; Gould, Md.; Scott, Ga.
Rosa carolina Linn. Koehler, Conn.
Rosa lucida Ehrh. Koehler, Conn.
Rosa virginiana Mill. Koehler, Conn.
Rosa rugosa Thunb. Britton, Koehler, Conn.
Willow (*Salix* sp.). Britton, Conn.; Felt, N. Y.; Sanderson, Del.
Salix lucida Muhl. Koehler, Conn.
Laurel-leaved willow (*Salix pentandra* Linn.). Lintner, N. Y.; Alwood, Va.
Salix vitellina Linn. Koehler, Conn.
Weeping willow (*Salix babylonica* Linn.). Lintner, N. Y.; Alwood, Va.
Salix humilis Marsh. Koehler, Conn.
Salix incana Schrank. Koehler, Conn.
Mountain ash (*Sorbus* sp.). Felt, N. Y.; Hunter, Kans.
American mountain ash (*Sorbus americana* Marsh). Britton, Koehler, Conn.; Alwood, Va.
European mountain ash (*Sorbus aucuparia* Linn.). Britton, Koehler, Conn.
Black chokeberry (*Sorbus melanocarpa* C. Koch [*Aronia nigra* Koehne]). Koehler, Conn.
Snowberry (*Symphoricarpos racemosus* Michx.). Felt, N. Y.; Smith, N. J.
Common lilac (*Syringa vulgaris* Linn.). Burgess, Ohio; commissioner of agriculture, N. Y.; Troop, Ind.; Alwood, Va.
Persian lilac (*Syringa persica* Linn.). Britton, Conn.
Basswood, linden (*Tilia* sp.). Britton, Conn.; Lintner, commissioner of agriculture, N. Y.
American linden or basswood (*Tilia americana* Linn.). Britton, Conn.; Alwood, Va.
Osage orange (*Toxylon pomiferum* Raf.). Britton, Conn.; Lintner, Felt, N. Y.; Alwood, Va.
Elm (*Ulmus* sp.). Lintner, N. Y.; Webster, Ohio; Troop, Ind.
American elm (*Ulmus americana* Linn.). Britton, Koehler, Conn.; Alwood, Va.
English or European elm (*Ulmus campestris* Smith). Britton, Conn.; Felt, N. Y.; Smith, N. J.

NATURAL ENEMIES.

The San Jose scale is subject to attack by numerous predacious and parasitic enemies, which render important service in its control. Practically, however, the combined influence of these several agencies is not sufficient to make up for the enormous reproductive capacity of this insect. To preserve the plants from destruction, its control must be accomplished by artificial means, such as the use of sprays.

Among the more common predacious insects which are observed feeding on the scale is the so-called pitiful ladybird,[1] illustrated in figure 7. This very small, convex, black beetle generally may be found by any observant person on scale-infested trees.

Another species that feeds very commonly on this and other scale insects is the twice-stabbed ladybird.[2] This is a very near relative and almost identical in appearance with the Asiatic ladybird [3] (fig. 8), which was introduced into this country from China through the

[1] (*Pentilia*) *Microweisea misella* Lec. [2] *Chilocorus bivulnerus* Muls. [3] *Chilocorus similis* Rossi.

activities of Mr. C. L. Marlatt, of the Bureau of Entomology, in the hope that its introduction would result in the control of this insect. The Asiatic ladybird, however, unfortunately proved to be subject to certain native parasites, while the necessity of spraying for the scale destroyed its food supply to such an extent that it was unable to maintain its existence.

In addition to the enemies just mentioned, there are certain very minute, four-winged flies (see fig. 9) belonging to the parasitic Hymenoptera, which are true parasites of scale insects. These place their eggs beneath the scales, some species attacking the scale insect

FIG. 7.—The pitiful ladybird: *a*, Beetle; *b*, larva; *c*, pupa; *d*, blossom end of pear, showing scales with larvæ of ladybird feeding on them, and pupæ of ladybird attached within the calyx. All greatly enlarged. (Howard and Marlatt.)

while others attack the eggs. The resulting grubs kill the insect or devour the eggs. When the parasite has become fully developed it escapes through a small, round hole which it gnaws through the scale. Parasitism of the San Jose scale by these insects can be determined by inclosing in a glass vial a badly infested twig, for in the course of a few days the minute flies, if present, will begin to emerge. Dr. L. O. Howard and Mr. R. A. Cushman have prepared a list of parasites[1] which have been reared from the San Jose scale.

[1] *Aphelinus fuscipennis* How., *Aphelinus mytilaspidis* LeB., *Aphelinus diaspidis* How., *Aspidiotiphagus citrinus* (Craw) (fig. 9), *Anaphes gracilis* How., *Physcus varicornis* How., *Prospaltella aurantii* How., *Prospaltella perniciosi* Tower, *Prospaltella fasciativentris* Gir., *Aberus clisiocampae* Ashm., *Rhopoideus citrinus* How., *Perissopterus pulchellus* How., *Arrhenophagus chionaspidis* Aurlv., *Anagrus spiritus* Gir., *Signiphora nigrita* Ashm., *Coccophagus immaculatus* How., *Coccophagus lecanii* Fitch, and *Microterys* sp.

While the benefits arising from the work of these parasites are undoubtedly great, the percentage of control of the scale thus accomplished varies greatly with the locality and the time of year, and from season to season. The highest percentage of parasitism thus far observed, and far in excess of the average, is 90. The remaining 10 per cent of healthy scales would suffice for reproduction of the scale in injurious numbers. It is, therefore, readily seen that, even with this high percentage of parasitism, the control of the scale by these agencies can not be depended upon.

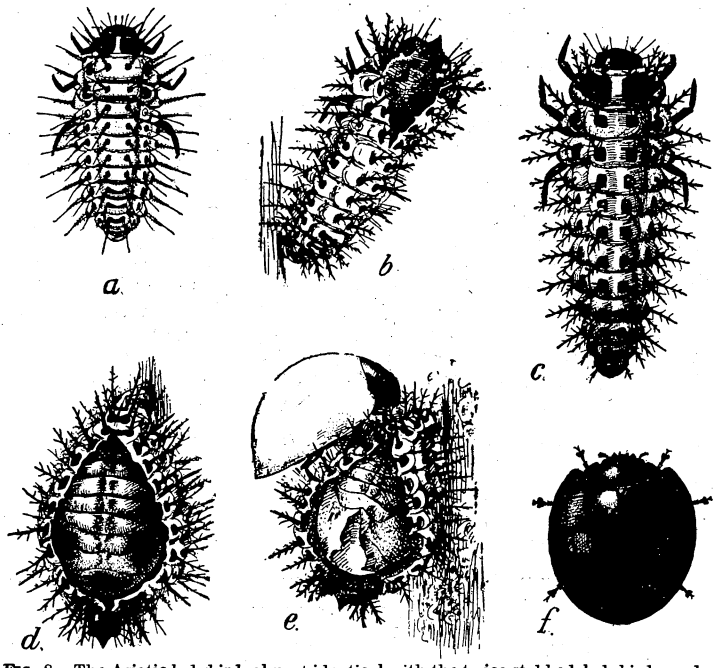

FIG. 8.—The Asiatic ladybird, almost identical with the twice-stabbed ladybird, predatory on the San Jose scale: *a*, Second-stage larva; *b*, cast skin of same; *c*, full-grown larva; *d*, method of pupation, the pupa being retained in the split larval skin; *e*, newly emerged adult not yet colored; *f*, fully colored and perfect adult. All enlarged to the same scale. (Marlatt.)

Considerable attention has been given to the subject of fungous diseases of the San Jose scale, and numerous attempts conducted in a thoroughly scientific manner, notably by Prof. P. H. Rolfs, director of the Florida Agricultural Experiment Station, have been made to utilize one of these parasitic plants in the control of the insect. The fungus in question (*Sphaerostilbe coccophila*), is cosmopolitan in its distribution, infesting many armored scale insects,[1] and in Florida and the territory adjacent to the Gulf it is quite generally present on scales in orchards and on shade and forest trees. Its abundance and effectiveness, however, depend upon certain weather conditions, and therefore vary considerably.

[1] Subfamily Diaspinae.

CONTROL MEASURES.

In the absence of treatment, the San Jose scale, as a rule, will quickly cause the death of or greatly injure many kinds of plants. Its discovery, therefore, whether in orchards or in prized fruit trees, shrubs, or other plants in the yard, should call for prompt measures for its control. Scarcely anyone now questions the fact that **the insect can be kept well in check by thorough annual treatment during the period when the plants are dormant.** The use of dilute lime-sulphur wash during the summer as a fungicide has in many apple orchards had the effect of destroying the young crawling lice to such an extent that the dormant treatment has occasionally been omitted without injurious results. The practice of occasionally omitting dormant scale treatment, however, should be adopted only

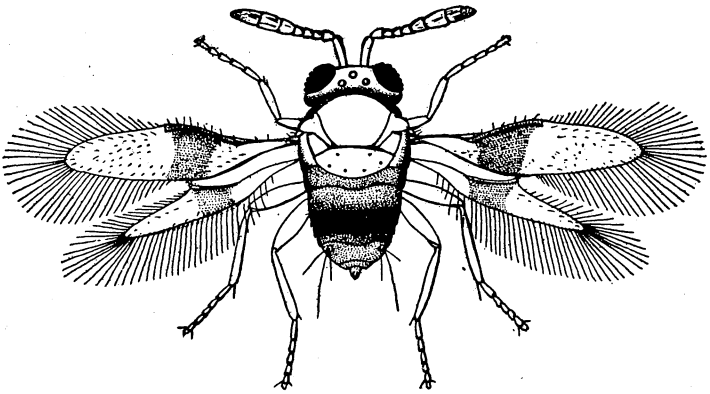

FIG. 9.—*Aspidiotiphagus citrinus*, a hymenopterous parasite of the San Jose scale. Greatly enlarged. (Howard.)

when it is quite clear that the scale is so much reduced that the absence of treatment for a year will not permit its undue increase to the injury of the trees and the disfigurement of the fruit.

Complaint sometimes comes from orchardists that the control of the scale is neglected by their neighbors. Undoubtedly the scale will spread from orchard to orchard, but **thorough annual sprayings will prevent important injury, regardless of neglect in adjacent orchards.**

Where plants are thoroughly incrusted, with consequent death of branches and stunting of growth, it will generally be advisable to dig out the trees or plants at once and replace these with new ones. Before spraying infested trees, the dead and weakened wood should be pruned out, which will simplify the work of spraying and hasten the formation of new sound wood. In the spring the trees should be stimulated into vigorous growth by the use of a nitrogenous fertilizer, such as nitrate of soda.

TIME OF APPLICATION.

Trees and plants should be sprayed during the dormant period. At this time the absence of foliage permits of more thorough work than during the summer, and the sprays can be used much stronger. Applications can be made (1) **in late fall after the foliage is down,** (2) at any time **during the winter when the temperature is above freezing,** or (3) **in the spring before the foliage appears.** When lime-sulphur solution is used, somewhat better results, it is thought, will follow applications made as late in the spring as feasible.

THE DELAYED DORMANT TREATMENT.

In recent years the so-called "delayed dormant" treatment has come into vogue, particularly in apple orchards in which plant-lice or aphids are troublesome.

The more important apple plant-lice pass the winter on the apple in the egg stage and are mostly hatched by the time the green shoots are pushing through the bud scales in the spring, and on these they congregate.

The plan is to delay the application of the winter-strength lime-sulphur solution until the buds begin to show green, and, by the addition to the spray of tobacco extract or nicotine, effect a combination treatment for the scale and the aphids. Principally nicotine sulphate, containing 40 per cent nicotine, is used at the rate of ¾ pint to 100 gallons of lime-sulphur spray. The nicotine destroys the hatched aphids that are hit with the spray, while the lime-sulphur, in addition to controlling the scale, destroys a large proportion of the eggs of the aphids on the trees, should any be still unhatched.

In orchards badly infested with the scale it is doubtful whether the grower should take chances with the delayed dormant treatment, especially in large orchards where the spraying takes considerable time. Unfavorable weather or other conditions may so delay spraying operations that the foliage will develop to such an extent that the use of dormant-strength lime-sulphur would endanger the leaves. Such late spraying, furthermore, would not be as effective as desirable in destroying the aphids, since most of these would be more or less protected by the foliage or would have penetrated the expanding shoots.

Figure 10 illustrates an apple bud with aphids clustered on it in about the right condition for the delayed dormant treatment. Figure 11 shows an apple bud with leaves so far out that the aphids are pretty well protected between the leaves, and the delayed dormant application would not be very effective in killing the aphids, and might cause some foliage injury.

WASHES IN USE AGAINST THE SAN JOSE SCALE.

There are several scale washes which may be employed in the control of the insect, and the one should be selected which can be most conveniently used and which is economical under the circumstances. Thus, for spraying on a large scale, the orchardists could properly afford expenditures for the construction of cooking outfits for lime-sulphur wash which would not be justified where only a few trees were involved. For a few plants it would be better to use some one of the prepared washes put up by manufacturers. In fact, many large orchardists prefer to use sprays of this class in preference to making the washes at home. The possibility of injury to the trees from the sprays must also be borne in mind. The aim is to use the wash about as strong as the tree will stand, thereby securing the maximum killing effect upon the insects. Used in this way the washes of the petroleum or kerosene series are most likely to cause injury to the fruit buds and tender twigs, and the lime-sulphur washes least likely to do so. Fish-oil soap sprays as recommended for dormant trees are comparatively safe, though reports are at hand of injury to fruit buds, especially from fall applications. Stone fruits, such as peach, plum, etc., are more susceptible to injury from sprays than apple and pear, and on the former the lime-sulphur sprays should always be used. Petroleum and miscible oils are more frequently used on apple and pear, and owing to their spreading and penetrating qualities are perhaps more effective in destroying the scales on the terminal twigs. The several sprays in use may be considered under the following headings: (1) Lime-sulphur wash series, (2) petroleum-oil series (including miscible oils), and (3) soap washes.

FIG. 10.—Apple bud with aphids clustered on it, in about right condition for delayed dormant treatment for San Jose scale and aphids. (Quaintance and Baker.)

LIME-SULPHUR WASH SERIES.

OLD FORMULA.

Several years ago the cooked lime-sulphur wash was used largely for the control of the San Jose scale but has now been generally

superseded by the commercial or homemade concentrates. The old formula and method of making, however, are given below:

Stone lime	pounds	20, or 2
Sulphur (commercial ground)	do	15, or 1½
Water to make	gallons	50, or 5

Heat in a cooking barrel or vessel about one-third of the total quantity of water required. When the water is hot, add all the lime and at once add all the sulphur, which previously should have been made into a thick paste with water. After the lime has slaked, about another third of the water, preferably hot, should be added and the cooking should be continued for one hour, when the final dilution may be made, using either hot or cold water, as is most convenient. The boiling due to the slaking of the lime thoroughly mixes the ingredients at the start, but subsequent stirring is necessary if the wash is cooked by direct heat in kettles. If cooked by steam, no stirring will be necessary. After the wash has been prepared it must be well strained as it is being run into the spray tank. It may be cooked in large kettles, or preferably by steam in barrels or tanks. This wash should be applied promptly after preparation, since, as made by this formula, there is crystallization of the sulphur compounds and consequent hardening of the sediment upon cooling.

FIG. 11.—Young apple shoot too far expanded for delayed dormant treatment for aphids and San Jose scale. (Quaintance and Baker.)

COMMERCIAL LIME-SULPHUR CONCENTRATES.

For a number of years manufacturers have had on the market concentrated solutions of lime-sulphur which have only to be diluted with water for use. These commercial preparations, if used at proper strength, are entirely satisfactory. Although somewhat more expensive than washes made according to the old formula, many commercial orchardists have adopted the commercial concentrates in preference to making the wash at home. Where only a limited amount of spraying is to be done, as in the average home orchard,

it will be especially convenient to use the commercial concentrates. Lime-sulphur concentrates usually may be purchased from local seedsmen, implement dealers, or druggists, and from the manufacturers. They should have a density of about 33° on the Baumé scale and at this strength should be used, for dormant trees, 6¼ gallons to make 50 gallons of spray, or 5 pints to make 5 gallons of spray.

HOMEMADE LIME-SULPHUR CONCENTRATES.

The question of the preparation at home of lime-sulphur concentrate which will not crystallize upon cooling, thus duplicating the commercial product, has been investigated by the Bureau of Entomology of the United States Department of Agriculture, as well as by numerous experiment-station entomologists, notably by Profs. Stewart, Cordley, Parrott, and others. It has been demonstrated that it is practicable for orchardists to prepare concentrated stock solutions of lime-sulphur for immediate or later use, and since there is a saving in costs, numerous orchardists employ this plan. The necessary details for the preparation at home of lime-sulphur concentrates are given below.

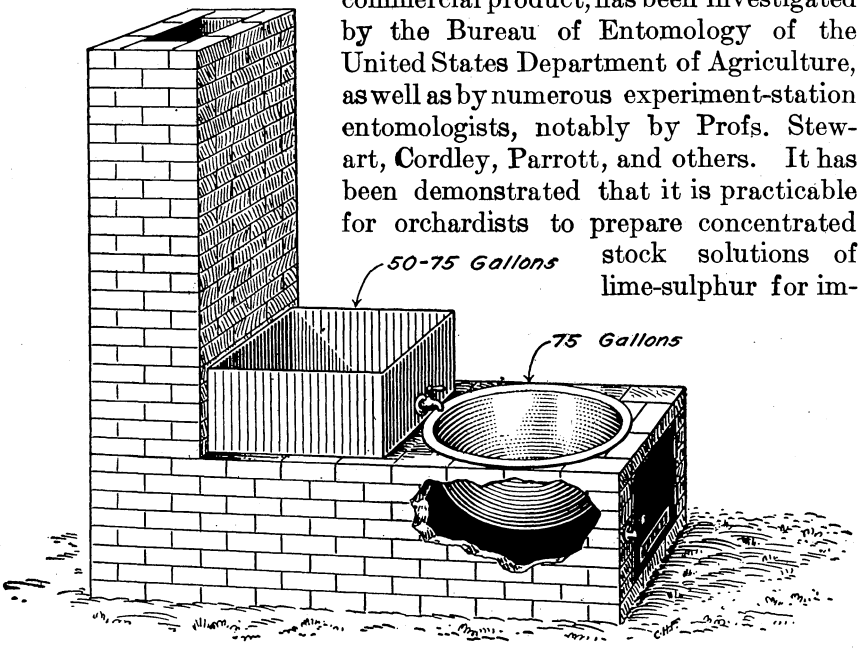

FIG. 12.—Lime-sulphur cooking outfit for preparing wash for small to medium-size orchards.

MATERIALS FOR MAKING.

Lime.—Use freshly burned stone lime, containing 90 per cent or over of calcium oxid. Hydrated lime, although not so desirable, may be substituted for the stone lime. If this form is used, it will be necessary to increase the amount of lime specified in the formula by at least one-third.

Sulphur.—Commercial sulphur, finely ground, is recommended. It is unnecessary to use the more expensive (sublimated) flowers of sulphur.

EQUIPMENT FOR MAKING.

Cooking apparatus.—Lime-sulphur concentrate may be made by orchardists with very simple appliances, such as a large kettle suspended on a pole or raised from the ground on loose stones. One or two such kettles embedded in masonry would be more convenient, however, and, being permanent, would warrant the installation of a convenient water supply. (See fig. 12.) Ordinary feed cookers or jacketed kettles are also very satisfactory. Small steam boilers of a few horsepower capacity serve especially well for a medium-sized orchard.

Where the amount of concentrate to be made is considerable, a more elaborate cooking plant is desirable. A convenient outfit is shown in Farmers' Bulletin 908.

Measuring stick.—When lime-sulphur concentrate is made on a small scale, a measuring stick will be of service in determining the amount of solution at any time during the cooking process. A suitable measuring device may be made from a strong strip of wood, the edges of which are plainly notched to indicate the number of gallons.

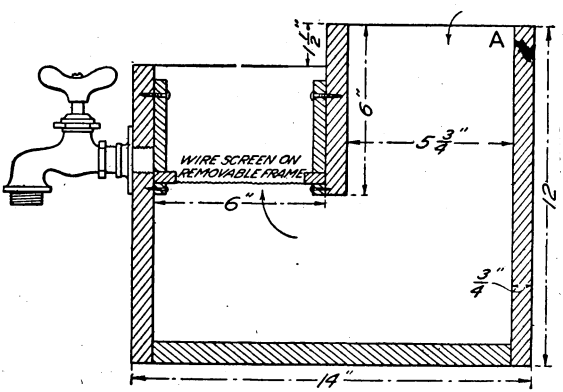

FIG. 13.—Strainer for removing sludge in lime-sulphur concentrate and other sprays.

Hydrometer.—A glass instrument known as a hydrometer (fig. 14) is used to determine the density of the lime-sulphur concentrate. (See p. 20.)

Strainer.—After the lime-sulphur has been made it should be strained before storage in order to remove the coarser undissolved particles. Any kind of strainer having either brass or tinned iron wire (never copper), 30 to 50 meshes to the inch, may be used. With the usual type of strainer, however, the sediment will clog the wire mesh more or less, and thereby will prevent the rapid flow of the solution through the screen. A strainer designed to overcome the clogging of the screen may be made upon the principle of the model shown in the illustration (fig. 13). With this type of strainer the material is poured in at A and is strained upward through the screen. The coarse particles settle to the bottom of the strainer instead of lodging on the screen, as in the ordinary type of strainer.

HANDLING AND STORAGE.

It is very desirable in most cases to make up a supply of lime-sulphur solution during the winter or early spring, before spraying

operations begin. It is quite feasible to do this, as the concentrated solution can be kept a year or more when properly stored. It should be placed in barrels or other tight receptacles and carefully stoppered, so as to exclude the air as much as possible, as this slowly causes the wash to deteriorate. The barrels or other container should be filled completely, so that there will be little or no air space above the contents. If the container is not filled completely, the concentrate should be covered with a layer of heavy oil or paraffin. In the preparation of the lime-sulphur concentrate at home the disposition of the sludge is a question of practical importance. Commercial manufacturing plants are usually supplied with a filter press by means of which the wash as it comes from the cooking tank is filtered, freeing it from sludge and sediment. There seems, however, to be no objection to storing the solution without removal of sludge, though the sediment should be strained out as already stated.

The strength of lime-sulphur concentrate may not be affected by freezing, but the expansion of the solution would be likely to damage the storage receptacles. It does not freeze easily, however, and the temperature at which it freezes varies with its strength; the stronger the solution the less easily it is frozen. It will stand a considerably lower temperature without freezing than will water.

FORMULAS.[1]

There are two general formulas, either of which may be used.

Formula A.

Fresh stone lime	pounds..	50, or 5
Commercial ground sulphur	do....	100, or 10
Water to make finished product	gallons..	50, or 5

Formula B.

Fresh stone lime	pounds..	80, or 8
Sulphur (commercial ground)	do....	160, or 16
Water to make finished product	gallons..	50, or 5

The density of the concentrate made according to formula A has varied, in the experience of the Bureau of Entomology, from 24° to 28° Baumé, and theoretically should be 26° by this scale. It is quite desirable, for economy in storage space, to prepare as highly concentrated a solution as possible. This can be done with reduced quantity of water according to formula B, which will give a solution of a density of from 32° to 34° Baumé. While this formula gives about 50 per cent in volume of sludge, after allowing the solution to settle for 24 hours there is only about 5 to 10 per cent in volume of insoluble material which would be removed in the straining process. This volume of sludge will not be objectionable in spraying, provided the insoluble material has been properly strained out.

[1] Scott, E. W. Homemade lime-sulphur concentrate. U. S. Dept. Agr. Bul. 197. 1915.

DIRECTIONS FOR PREPARATION.

To make a 50-gallon batch of the lime-sulphur concentrate, proceed in the following manner:

Place 10 gallons of water in the cooking vessel and start the fire or release the steam. Weigh out the lime and sulphur. The sulphur may be used dry, provided all the lumps are broken, or it may be made into a thin paste, and may be placed in the cooker before or after the lime has started to slake. When slaking is under way the materials must be stirred vigorously, and this agitation should be continued now and then throughout the boiling. Continue adding water, as required, until the lime is slaked; then, if cooking by fire, bring the contents up to 55 gallons and boil for 50 minutes to one hour. When steam is employed fill the cooker up to the 50-gallon mark. No excess water is needed, since the condensation of the steam about equalizes the amount of water lost through evaporation. The finished product should measure 50 gallons.

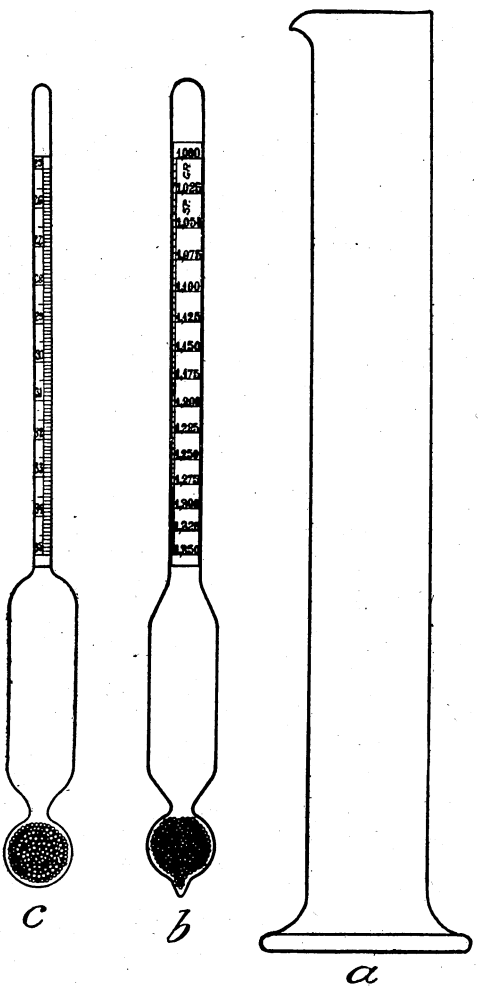

FIG. 14.—Apparatus for determining specific gravity of lime-sulphur concentrate: *a*, Cylinder for liquid to be tested; *b*, specific gravity spindle; *c*, Baumé spindle.

DILUTION.

It is very important to test with a hydrometer (fig. 14) the strength of all lime-sulphur solutions, to determine the proper amount of the concentrate that should be used for a given quantity of water. There are two kinds of these hydrometers, one with the Baumé scale and the other with the specific-gravity scale, and hydrometers may be purchased which have both scales on the same instrument. The Baumé scale hydrometer is most commonly used. The clear solution at a temperature of about 60° F. should be used for the

testing. If, however, the sludge has not been filtered out, the contents of the barrel or other container should be thoroughly stirred before the required amount for testing is taken out. The amount of dilution for concentrates for each degree Baumé from 20 to 36, and the corresponding specific-gravity reading, can be determined from Table I.

TABLE I.—*Dilution table for concentrated lime-sulphur solutions.*

Degrees Baumé.	Specific gravity.	Number gallons concentrated lime-sulphur to make 50 gallons spray solution.			Degrees Baumé.	Specific gravity.	Number gallons concentrated lime-sulphur to make 50 gallons spray solution.		
		Summer or foliage strength.	Winter or dormant strength.				Summer or foliage strength.	Winter or dormant strength.	
			San Jose scale.	Blister mite.				San Jose scale.	Blister mite.
36	1.330	1¼	5¼	4¾	27	1.229	2	8	6¾
35	1.318	1¼	5¾	5	26	1.218	2	8¼	7¼
34	1.306	1½	6	5	25	1.208	2	8¾	7½
33	1.295	1½	6¼	5¼	24	1.198	2¼	9¼	8
32	1.283	1½	6¾	5¾	23	1.188	2¼	9¾	8¼
31	1.272	1¾	6¾	5¾	22	1.179	2¼	10¼	8¾
30	1.261	1¾	7	6	21	1.169	2½	11	9¼
29	1.250	1¾	7¼	6¼	20	1.160	2½	11½	9¾
28	1.239	1¾	7½	6½					

In winter spraying for the San Jose scale and the pear-leaf blister mite about 5 per cent more of the solution should be used than the table of dilutions indicates, if the sludge has not been filtered out. In summer spraying, however, no allowance for sludge is necessary as a large percentage of this is composed of finely divided sulphur, which is of value.

LIME-SULPHUR SOLUTIONS FOR SUMMER SPRAYING OF POME FRUITS.

The discussion of lime-sulphur solutions on the preceding pages has related to their use on trees in a dormant condition. It sometimes happens that owing to unfavorable weather conditions during the time of the dormant spraying, or for other reasons, the application was not made satisfactorily, and it becomes desirable to spray the trees during the summer.

Under these circumstances much benefit will follow summer spraying for the San Jose scale, but this work should be regarded as a temporary expedient to prevent undue increase of the insect until the more effective dormant treatment may be applied.

Either the commercial or homemade lime-sulphur concentrate may be used for summer spraying (except on stone fruits), but they must be used in a much more dilute condition than during the winter. The dilute lime-sulphur solution has come into very extended use as a fungicide [1] and is used on pome fruits at the rate of 1½ gallons of

[1] Quaintance, A. L., and Scott, W. M. The more important insect and fungous enemies of the fruit and foliage of the apple. U. S. Dept. Agr. Farmers' Bul. 492. 1912.

the concentrate, registering from 32° to 34° on the Baumé scale, to 50 gallons of water. The use of the lime-sulphur solution as a fungicide will assist much in controlling the scale, provided attention is given in spraying to coat, in addition to the leaves and fruit, the limbs, branches, and twigs.

Young scale insects from individuals which may have escaped the dormant treatment have a decided tendency to migrate onto the fruit. The presence of these insects on the fruit is very objectionable, especially on apples intended for export trade, as scale-infested fruit is excluded from entry by certain foreign Governments, and is discriminated against by buyers generally. The summer use of the diluted lime-sulphur spray largely protects the fruit against the young scale insects.

SELF-BOILED LIME-SULPHUR MIXTURE FOR SUMMER SPRAYING OF STONE FRUITS.

Summer spraying of peach trees and other stone fruits for the San Jose and similar scale insects may also be desirable because of ineffective work during the dormant period of the trees. Under such circumstances the self-boiled lime-sulphur mixture should be used, since the foliage of the stone fruits will not stand the diluted lime-sulphur concentrate previously indicated for the apple, pear, etc. This self-boiled lime-sulphur mixture is made up according to quite a different formula from any of the washes heretofore mentioned, and has come into general use as a fungicide for the control of peach scab and brown rot and, with the addition of arsenate of lead, the plum curculio.[1] Orchardists spraying for these troubles on peaches and other stone fruits may at the same time accomplish much in preventing the increase of the scale by thoroughly coating the limbs and branches of the trees while making the applications to the foliage and fruit for the control of the fungous troubles mentioned.

The self-boiled lime-sulphur mixture may be made as follows:

Stone lime	pounds..	8, or 2
Sulphur (commercial ground [2] or flowers)	do....	8, or 2
Water to make	gallons..	50, or 12½

The lime should be placed in a barrel and enough water poured on almost to cover it. As soon as the lime begins to slake the sulphur should be added, after it has been first run through a sieve to break up the lumps. The mixture should be stirred constantly and more water added as needed to form a thick paste at first and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked cold water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied.

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[1] Scott, W. M., and Quaintance, A. L. Spraying peaches for the control of brown-rot, scab, and curculio. U. S. Dept. Agr. Farmers' Bul. 440. 1911.

[2] Commercial ground sulphur is the cheaper and is equally as satisfactory as the flowers of sulphur.

The stage at which cold water should be poured on to stop the cooking varies with different grades of lime. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking, and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot 15 or 20 minutes after the slaking is completed the sulphur gradually goes into solution, combining with the lime to form sulphids, which are injurious to peach foliage. It is therefore very important, especially with hot lime, to cool the mixture quickly by adding a few buckets of water as soon as the lumps of lime have slaked down. The intense heat, violent boiling, and constant stirring result in a uniform mixture of finely divided sulphur and lime, with only a very small percentage of the sulphur in solution. It should be strained to take out the coarse particles of lime, but the sulphur should be carefully worked through a strainer. The mixture can be prepared in larger quantities if desired, say enough for 200 gallons at a time, making the formula 32 pounds of lime and 32 pounds of sulphur to be slaked with a small quantity of water (8 or 10 gallons) and then diluted to 200 gallons. To make other quantities of the mixture see dilution table (p. 22).

COMMERCIAL POWDERED SULPHUR COMPOUNDS.

Within the past few years certain manufacturers have offered for sale, in a dry powdered condition, compounds of sulphur which are to be dissolved in water for the preparation of the spray. These compounds when used at sufficient strength should be satisfactory as dormant tree sprays and certain of them as summer sprays, and if so will undoubtedly meet with prompt favor with orchardists, since by their use there is a distinct saving in freight, and they are much more convenient in handling and storing.

PETROLEUM-OIL SERIES.

Under the heading "Petroleum-oil series" are to be included kerosene and crude petroleum, either pure or in emulsion, and the so-called miscible oils.

PURE KEROSENE.

Pure kerosene has been recommended to a greater or less extent for spraying trees badly infested with the scale, but it has never been very generally employed. There is no question of the efficiency of such an application in the destruction of the insects, but the great danger of injury to the plants precludes its general application. Treatments of pure kerosene should be made only to dormant trees and during bright days and should be applied through a nozzle with a very fine aperture. Only the minimum amount of kerosene necessary to cover the trees should be given, and care is necessary that the liquid does not puddle around the roots of the trees.

PURE CRUDE PETROLEUM.

Pure crude petroleum is used in identically the same manner as pure kerosene, and the same cautions as to its use should be remembered. The crude oil employed in the East is known as "insecticide oil" and has a specific gravity of 43° to 45° on the Baumé scale.

KEROSENE EMULSION (STOCK SOLUTION 66 PER CENT OIL).

Kerosene emulsion is made after the following formula:

Kerosene (coal oil, lamp oil)	gallons	2
Fish-oil soap or laundry soap (or 1 quart of soft soap)	pound	½
Water	gallon	1

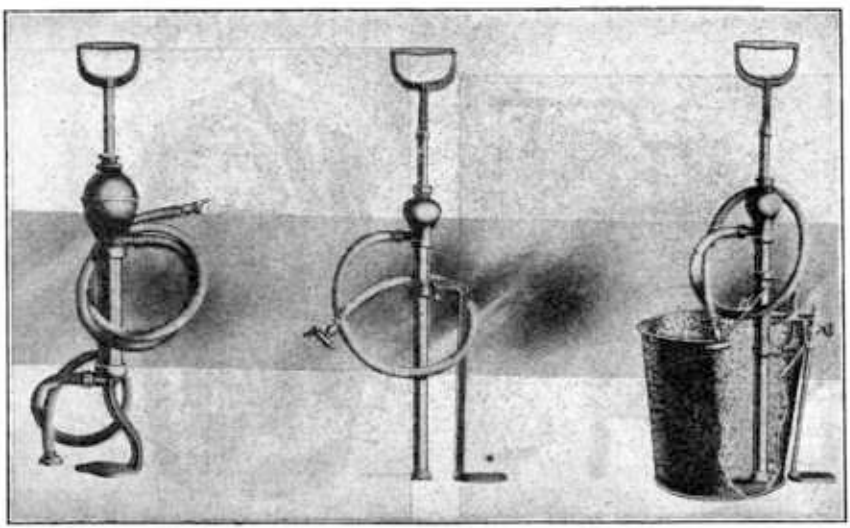

FIG. 15.—Bucket spray pump suitable for use in yards.

Dissolve the soap in boiling water; then remove the vessel from the fire. Immediately add the kerosene and thoroughly agitate the mixture until a creamy solution results. The stock emulsion may be more conveniently made by pouring the mixture into the tank of a spray pump and pumping the liquid through the nozzle back into the tank for some minutes. The stock solution, if well made, will keep for some months, and is to be diluted before using. In order to make a 10 per cent spray (the strength for trees in foliage), add to each 1 gallon of the stock solution about 5⅔ gallons of water. For 20 and 25 per cent emulsions (for use on dormant trees and plants), use, respectively, about 2⅓ gallons and 1⅔ gallons of water for each 1 gallon of stock emulsion. Agitate the mixture in all cases after adding the water. The preparation of the emulsion will be simplified by the use of a naphtha soap. No heat will then be required, as the kerosene will combine readily with the naphtha soap in water when

thoroughly agitated. Of naphtha soap, however, double the quantity given in the foregoing formula will be required, and soft or rain water should be used in making the emulsion. In regions where the water is "hard" this should first be broken with a little caustic potash or soda, such as common lye, before use for dilution, to prevent the soap from combining with the lime or magnesia present, thus liberating some of the kerosene; or rain water may be employed.

CRUDE-PETROLEUM EMULSION.

Crude-petroleum emulsion may be prepared in identically the same way as kerosene emulsion, substituting crude petroleum for kerosene. The same dilutions for winter and summer spraying should be made

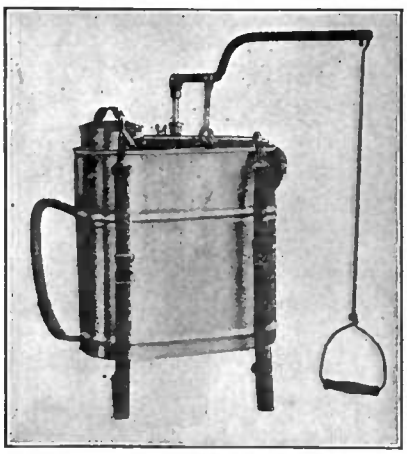

FIG. 16.—Knapsack sprayer suitable for spraying low-growing plants.

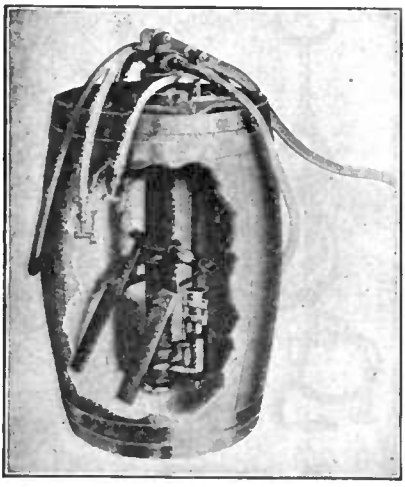

FIG. 17.—Barrel sprayer suitable for orchard or similar large-scale work.

as prescribed for kerosene emulsion, but it should be noted that for summer treatments of trees in foliage the kerosene emulsion is preferable, as it is less likely to cause injury.

MISCIBLE OILS.

Under the heading "Miscible oils" are to be designated several proprietary preparations which are essentially petroleum oils with the addition of a vegetable oil and an alkali, to secure ready saponification with water. These come in concentrated solutions and the spray is prepared by adding a specified amount of water. In point of convenience they leave little to be desired. Miscible oils have come into use in place of kerosene or crude petroleum, either pure or in emulsions, and have a distinct usefulness as winter sprays about the same as have the concentrated lime-sulphur solutions. As has been indicated, the petroleum oils are at times the cause of injury

to twigs and fruit buds, in extreme cases killing the trees. It is a question of judgment whether, under conditions of severe scale infestation, the petroleum oils or the sulphur solutions should be used. The petroleum oils, on the whole, are more effective and the danger of injury from them is less to pome than to stone fruits.

The practicability of making miscible oils at home has been investigated by Prof. C. L. Penny, and he has shown it to be entirely feasible. Information on this subject will be found in Farmers' Bulletin 908, United States Department of Agriculture.

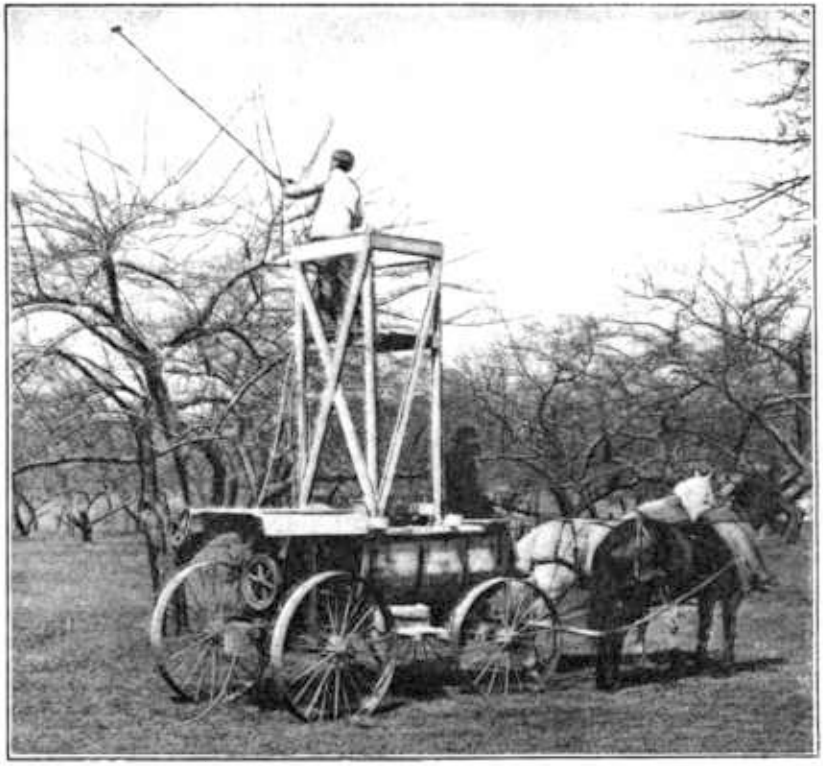

FIG. 18.—Gasoline power spraying outfit for use in large orchards.

SOAP WASHES.

Practically the only soap wash which has come into extended use against the San Jose scale is that made from fish oil. Fish-oil soap is used mostly on dormant trees, being employed at the rate of 2 pounds to the gallon of water.

A potash fish-oil soap is preferable and should contain not more than 30 per cent of water. Soda soaps, while perhaps cheaper, will be likely to solidify on cooling when used at the strength just indicated,

and hence are forced through the spray-nozzle with difficulty. For spraying trees in foliage the soap should be used at the rate of 1 pound to 3 or 4 gallons of water, or somewhat weaker.

SPRAYING APPARATUS.

For the successful application of sprays to trees and plants infested with the San Jose scale some form of spraying apparatus is necessary. For small plants, as low trees, ornamental hedges, etc., a bucket pump (fig. 15) or a knapsack pump (fig. 16) will be satisfactory. The barrel pump (fig. 17) will permit of more thorough work and will be suitable for orchards of some size. It may be placed in a wagon or cart or mounted on a sledge. For large commercial orchards the hand-power tank, or gasoline outfits, are, of course, employed. (See fig. 18.) It is quite practicable, in case only a few trees in the yard are to be treated, to apply the wash on the limbs and branches by means of a brush, or even with old cloths. Fish-oil soap is excellent in such cases. Severe pruning of the trees usually is desirable to simplify the work of treatment, and also to produce a new growth of noninfested wood.

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